

1 Circulation Tool

2
3 The present invention relates to a downhole tool for
4 circulating fluid in a well bore and in particular,
5 though not exclusively, to a circulation tool which can
6 be selectively locked in an opened or closed
7 configuration while in tension or compression.

8
9 At various times during the drilling, completion and
10 production of an oil or gas well, it may be necessary to
11 circulate fluid within the well bore. This is typically
12 done by running a tool on a workstring, the tool having a
13 cylindrical body with radial ports, through which fluid
14 from the bore of the workstring can pass. The procedure
15 can provide a cleaning action and/or provide a transport
16 system to carry debris and other materials from the well
17 bore to the surface in the circulating fluid.

18
19 A known circulating tool is that disclosed in GB 2272923.
20 This tool for circulating fluid in a well bore comprises
21 a body member having a radial fluid outlet. An isolation
22 sleeve is movably mounted on the body member for movement
23 between an open position in which fluid may flow out of

1 the outlet and a closed position. The isolation sleeve is
2 moved to its open position against the action of spring
3 by engaging a shoulder with the top of a liner and
4 setting down on the tubing string. Alternatively, the
5 outlet is opened when the lower end of the tubing string
6 engages the bottom of the well bore.

7
8 This tool has a number of disadvantages. The tool can
9 operate only by contacting a formation in the well bore
10 e.g. a liner top or bottom of the well, and thus cannot
11 be operated at any desired location in the well bore. In
12 contacting a formation the tool is held in compression
13 which limits other functions which can be performed from
14 the work string when fluid is circulated through the
15 tool. Further any spurious debris in the well bore, or
16 indeed sudden pressure changes within the well bore can
17 cause the tool to operate prematurely.

18
19 US 6,152,228 provides a circulation tool which overcomes
20 the problem of premature operation. The tool comprises a
21 tubular assembly which has an axial through passage
22 between a fluid inlet and first fluid outlet. The fluid
23 inlet and the first fluid outlet are connected in a work
24 string which is supported from the surface above the well
25 bore. There is a second outlet which extends generally
26 transversely of the assembly. An obturating member is
27 moveable between a first position in which the second
28 fluid outlet is closed and a second position which
29 permits fluid flow through the second outlet. An
30 engagement mechanism is moveable between an engaged
31 configuration in which the obturating member is
32 maintained in one of the first and second positions, and
33 a disengaged configuration in which the obturating member

1 is in the other of the first and second positions. The
2 tubular assembly is coupled to a shoulder which is
3 engageable with the formation in the well bore to engage
4 or disengage the engagement mechanism. Setting down
5 weight on the work string causes a formation of the well
6 bore to exert a force on the shoulder which results in
7 the second outlet being opened.

8

9 As the engagement mechanism allow the tool to be
10 maintained in either the open or closed configuration,
11 the tool cannot be prematurely set. However, the major
12 disadvantage of this tool is that its use is limited to
13 locations within the well bore where a formation exists
14 so that the tool must be placed in compression to switch
15 configuration.

16

17 It is an object of the present invention to provide a
18 circulation tool which can be selectively opened and
19 closed without the need to set down weight on the tool or
20 contact a formation in the well bore.

21

22 It is a further object of at least one embodiment of the
23 present invention to provide a circulation tool which can
24 be locked in an open or closed configuration to operate
25 the tool in tension or compression.

26

27 It is a still further object of at least one embodiment
28 of the present invention to provide a method of operating
29 a circulation tool by varying fluid pressure through the
30 tool from pumps located above the tool.

31

32 According to a first aspect of the present invention
33 there is provided a tool for circulating fluid in a well

1 bore, the tool comprising a tubular assembly having a
2 through passage between an inlet and a first outlet, the
3 inlet and first outlet being adapted for connection in a
4 work string, a second outlet extending generally
5 transversely of the tubular assembly of the tubular
6 assembly;

7
8 an obturating member moveable between a first position
9 closing the second outlet and a second position
10 permitting fluid flow through the second outlet, the
11 obturating member including restraining means to actively
12 retain the obturating member independently in the first
13 and the second positions;

14
15 an engagement mechanism actuatable between an engaged
16 configuration, in which the obturating member is locked
17 in one of the first or second positions; and a disengaged
18 configuration in which the obturating member can move to
19 the other of the first and second positions;

20
21 a fluid pressure actuation surface coupled to the
22 engagement mechanism and biased by a spring located
23 between the tubular assembly and the engagement
24 mechanism;

25
26 wherein variation of fluid pressure on the actuation
27 surface controls actuation of the engagement mechanism
28 and stroking the tool in the disengaged configuration
29 moves the obturating member.

30
31 Preferably the obturating member comprises a sleeve
32 axially slidable within the tubular assembly. Preferably
33 the restraining means is a collet. The collet may be

1 retainable in a plurality of recesses on the tubular
2 assembly.

3

4 Preferably the fluid pressure actuation surface is
5 located on an actuator sleeve axially slidable within the
6 tubular assembly. More preferably a portion of the
7 actuator sleeve can locate across the collet.

8

9 Preferably the engagement mechanism comprises mutually
10 engageable formations on each of the actuator sleeve and
11 the tubular assembly. More preferably the formations
12 comprise a pin and a groove. Advantageously the groove is
13 continuous so that the pin can travel in a continuous
14 cycle around the groove. Preferably the groove comprises
15 a plurality of apexes and bases such that the pin moves
16 longitudinally to the tubular assembly. The distance of
17 longitudinal travel will determine whether the engagement
18 mechanism is in the locked or disengaged position.

19

20 Preferably also the second outlet comprises a plurality
21 of ports in the tubular assembly which communicate with
22 the inlet. Typically the ports may be distributed
23 circumferentially around the outer surface of the tubular
24 assembly.

25

26 Typically the cross-sectional area of the first outlet is
27 greater than the cross-sectional area of the second
28 outlet.

29

30 The ports may be designed to direct the fluid exiting the
31 second outlet in an uphole or downhole direction into the
32 well bore.

33

1 According to a second aspect of the present invention
2 there is provided a method for circulating fluid in a
3 well bore, the method comprises the steps:

- 4 (a) inserting a work string into the well bore, the work
5 string having a fluid inlet, a first fluid outlet
6 and a second fluid outlet, an obturating member
7 which is moveable between a first and second
8 position to respectively close and open the second
9 fluid outlet, and an engagement mechanism which when
10 engaged locks the obturating member in one of the
11 first or second positions;
12 (a) varying the fluid pressure through the work string
13 to move the engagement mechanism between locked and
14 unlocked configurations; and
15 (b) stroking the work string to move the obturating
16 member between the first and second positions.

17
18 Preferably varying the fluid pressure through the work
19 string is achieved by pumping fluid through the work
20 string.

21
22 Preferably the method includes the step of running the
23 work string in a closed and locked configuration with the
24 pumps turned off.

25
26 Preferably the method includes the step of drilling with
27 the work string in a closed and locked configuration and
28 in compression while pumping fluid.

29
30 Preferably the method includes the step of back reaming
31 with the work string in a closed and unlocked
32 configuration and in tension while pumping fluid.

33

1 Preferably also the method includes the step of opening
2 the second outlet with the work string in tension with
3 the pumps off.

4
5 Preferably also the method includes the step of stroking
6 the work string in a locked and open configuration while
7 pumping fluid.

8
9 Preferably also the method includes the step of stroking
10 the work string in a locked and open configuration with
11 the pumps off.

12
13 Preferably the method includes operating the work string
14 in a cyclic manner through the following configurations:

- 15 (a) locked closed;
16 (b) unlocked closed;
17 (c) unlocked open;
18 (d) locked open;
19 (e) unlocked open; and
20 (f) unlocked closed.

21
22 An embodiment of the present invention will now be
23 described, by way of example only, with reference to the
24 following drawings of which:

25
26 Figure 1 is a part cross-sectional view of a tool for
27 circulating fluid in a well bore according to an
28 embodiment of the present invention;

29
30 Figure 2 is a schematic view of the profile of the groove
31 in the index sleeve of the tool of Figure 1;

32

1 Figure 3 is a view through the section line A-A' of
2 Figure 1; and

3
4 Figure 4 is a part view through the section line B-B' of
5 Figure 1.

6
7 Reference is initially made to Figure 1 of the drawings
8 which illustrates a tool, generally indicated by
9 reference numeral 10, for circulating fluid in a well
10 bore. Tool 10 has an upper end 12 comprising a top sub 14
11 being a cylindrical body and including a box section 16
12 for connecting the tool 10 to a work string or drill
13 string. Located below the top sub 14 and connected
14 thereto is a spring housing 18. Spring housing 18 is a
15 substantially cylindrical body whose inner surface 20
16 includes a shoulder 22 against which a spring 24 is
17 located. A radial port 26 is arranged through the spring
18 housing 18 through which an index pin 28 is located.
19 Though only a single index pin 28 is shown, more than one
20 index pin may be used. In the preferred embodiment two
21 index pins 28 are arranged opposite each other.

22
23 Located below the spring housing 18 and connected thereto
24 is a collet housing 30. Collet housing 30 comprises a
25 tubular body with an inner surface 32. Arranged on inner
26 surface 32 are two concentric recesses 34, 36. Arrange
27 through the body are radial ports 38. In the preferred
28 embodiment there are four radial ports arranged
29 equidistantly around the housing body. A further access
30 port 40 is provided in the housing 30 through which a
31 plug and grease nipple arrangement 42 is positioned.
32

1 Located below the collet housing and connected thereto is
2 a hex drive 44. Hex drive 44 comprises a cylindrical body
3 having an inner surface 46 of which a portion 48 is
4 hexagonal. At an upper end of the portion 48 is located a
5 ledge 50. The hex drive 44 is positioned over a bottom
6 sub 52 which extends therefrom. Bottom sub 52 includes a
7 pin section 54 at a lower end for connection into a work
8 string or drill string. A shoulder 62 is located to
9 engage the ledge 50. The sub 52 also includes a hexagonal
10 mating portion 56 to match the portion 48 on the hex
11 drive 44. This is shown with the aid of Figure 3 which
12 demonstrates the hex profile matching between the hex
13 drive 44 and the bottom sub 52. In this way rotation of
14 the hex drive 44 will be transmitted to the bottom sub
15 52.

16

17 The top sub 14, spring housing 18, collet housing 30, hex
18 drive 44 and bottom sub 52 provide an outer surface 58 to
19 the tool 10 while principally defining a central bore 60
20 through the tool for fluid communication with the work
21 string. Rotation of the work string will be transmitted
22 through the entire assembly regardless of whether fluid
23 is being circulated out of the tool.

24

25 Arranged within the central bore 60 against the collet
26 housing 30 is a collet assembly 64. Assembly 64 is
27 substantially cylindrical to allow the passage of fluid
28 through the central bore 60. The assembly includes, at
29 its upper end eight sprung pins 66 which are biased in an
30 outwardly radial direction. These pins 66 are shown in
31 cross-section in Figure 4, illustrating the bulbous heads
32 which are sized to fit within recess 34 or recess 36 on
33 the collet housing 30. Assembly 64 includes radial ports

1 68 arranged equidistantly around and through the assembly
2 64. Preferably there are four ports 68 to match the four
3 ports 38 on the collet housing 30. The collet assembly 64
4 is located against the housing 30 to provide a channel 70
5 around the ports 68. The channel is sealed via a wear
6 ring 72 and o-rings 74 located at each end of the channel
7 70. The channel 70 allows the ports 68, 38 to be near
8 alignment for fluid to flow from the central bore 60 to
9 the outer surface 58 of the tool 10. A further set of o-
10 rings 76 are located between a lower end of the assembly
11 64 and the housing 30 such that, when the ports 68, 38
12 are sufficiently misaligned and the passage for fluid is
13 blocked, the ports 38 on the housing 30 are sealed to
14 prevent the ingress of fluid between the housing 30 and
15 the assembly 64.

16

17 Also located within the bore 60 is a collet support
18 sleeve 78. Sleeve 78 is sized to locate over the sprung
19 pins 66 of the collet assembly 64 and hold them in place
20 within recess 34 or recess 36 as desired. The sleeve 78
21 can also locate above the collet assembly 64 leaving the
22 pins 66 free to move within the central bore 60 against
23 the inner surface 32 of the collet housing 30. An upper
24 end 80 of sleeve 78 is connected to an actuator sleeve
25 82. The connection includes a bearing ring. Thus sleeve
26 78 is moved by virtue of actuation of the actuator sleeve
27 82. Actuator sleeve 82 has an inner surface 84 located
28 against the central bore 60. At an upper end 86 of the
29 sleeve 82 is a conical surface 88. Surface 88 is a fluid
30 pressure actuated surface. At the base of the surface 88
31 is located a choke ring 90. Surface 88 and choke ring 90
32 together ensure that variations in fluid pressure through
33 the central bore 60 can cause movement of the actuator

1 sleeve 82. At the upper end 86 facing the inner surface
2 20 of the spring housing 18 is a shoulder 92. Shoulder 92
3 is oppositely opposed to shoulder 22 of the spring
4 housing 18. Between the shoulders 22,92 is arranged the
5 spring 24. The shoulder 22 is fixed and thus movement of
6 the actuator sleeve 82 downward is against the bias of
7 the spring 24.

8

9 Adjacent the spring 24, between the actuator sleeve 84
10 and the spring housing 18 is located a cylinder sleeve
11 94. O-rings 96 seal the cylinder sleeve 94 against the
12 actuator sleeve 84 but they do not prevent relative
13 movement occurring between the sleeves. Cylinder sleeve
14 94 is held in position by virtue of the index pin 28
15 located through the access port 26 on the spring housing
16 18. Pin 28 locates through the cylinder sleeve 94 and
17 into an index sleeve 98. Index sleeve 98 is located in a
18 recess 100 of the actuator sleeve 84 with bearing rings
19 located at each end thereof. Thus movement of the
20 actuator sleeve 84 can move the index sleeve 98 and
21 likewise arrest of the index sleeve 98 can prevent
22 movement of the actuator sleeve 84. Additionally the
23 index sleeve 98 can rotate without the rotating the
24 actuator sleeve 84.

25

26 On an inner surface 102 of the index sleeve 98 is located
27 a groove or profile 104. This is best seen with the aid
28 of Figure 2 which shows the developed circumference of
29 the index sleeve 98. In the Figure shown there are two
30 index pins 28 making an identical path through the
31 profile 104. The index pins 28 are shown located in a
32 small apex 106. Actuation on the sleeve 98 will cause the
33 pins to move to a first base 108. The bias on spring 24

1 will move the pins 28 to a high apex 110 providing the
2 greatest longitudinal movement of the sleeve 98. On
3 return the pins will locate in a second base 112. As will
4 be appreciated the pins 28 can cycle continuously around
5 the sleeve 98 and consequently the movement of the
6 actuator sleeve 84 can be controlled. When the pins 28
7 are located in the small apex the actuator sleeve 84 is
8 effectively locked in position. A longitudinal wall on
9 the first base side prevents accidental movement into the
10 high apex 110, and movement in the opposite direction
11 causes the pin 28 to fall into the second base 112.

12

13 In use, the tool is inserted into a a drill string and
14 connected thereto by use of the box section 16 and the
15 pin section 54. We will describe the operation of the
16 tool cycling from a closed and locked position to an
17 identical position. It will be understood that the tool
18 can be cycled from any starting position in the cycle and
19 thus the tool run into a well bore in any configuration
20 and pulled from the well bore in any configuration.

21

22 Additionally it will be appreciated that although the
23 description has referred to terms such as upper, lower,
24 above, below, these are all relative. The tool of the
25 present invention finds equal application in non-vertical
26 wells such as those that are inclined or horizontal.

27

28 The tool 10 is run on the drill string into the well bore
29 in a locked closed configuration. In this configuration
30 the index pins 28 are located in the small apex 106 of
31 the profile 104 on the index sleeve 98. This 'locks' the
32 index sleeve 98 in position and with it the actuator
33 sleeve 84 and the collet support sleeve 78. Collet

1 support sleeve 78 extends over the sprung pins 66 of the
2 collet assembly 64 and thus holds the sprung pins 66 in
3 the upper recess 34. Radial ports 68 and 38 are thus
4 misaligned and the tool is 'closed'. Fluid flow is only
5 through the central bore 60.

6
7 In order for drilling to take place from the end of the
8 drill string, fluid is required to be pumped through the
9 central bore. The drilling action compresses the drill
10 string and thus the tool 10 is in compression. Fluid
11 pressure on the pressure surface 88 causes movement of
12 the actuator sleeve and with it the index sleeve 98.
13 Index pin 28 moves to the first base 108 and the
14 compression prevents it from moving into the high apex
15 112. Loading within the tool is on the shoulder 62. This
16 effectively is a downstroke. The tool remains locked and
17 closed. On the upstroke, occurring when drilling stops
18 and back reaming for instance starts, the drag forces
19 created by the weight of tools on the string below tool
20 10 causes tool 10 to go into tension. The index pin 28
21 remains in the first base 108 and the tool is still in
22 the locked and closed position. Loading, however, has
23 shifted from shoulder 62 to the sprung pins 66 against
24 the recess 34.

25
26 Turning the pumps off to lower fluid pressure in the tool
27 10 and again stroking the tool, causes the collet support
28 sleeve 78 to raise and clear the sprung pins 66 on the
29 downstroke and move the sprung pins 66 to the lower
30 recess 36 on the upstroke. The index pin 28 is now
31 located in the high apex 110. Movement of the sprung pins
32 66 to the lower recess 36 causes lowering of the collet
33 assembly 64 within the tool 10. Channel 70 now locates

1 across the radial ports 38 and fluid can thus circulate
2 from the bore 60 through the ports 68 and out of the tool
3 10 to the outer surface 58 via ports 38. The tool 10 is
4 'open'.

5

6 To 'lock' the tool 'open' the pumps are turned on and
7 pumping is maintained at a sufficiently high rate to
8 cause movement of the actuator sleeve 84 against the
9 spring 24 by fluid pressure on the pressure surface 88.
10 The collet support sleeve 78 moves across the sprung pins
11 66 to hold them in the lower recess 36. Index pin 28 is
12 moved to the second base 112. The ports will remain open
13 in this configuration even if the tool 10 is moved up and
14 down in a well bore or back and forth in an inclined well
15 bore. Stoking the tool merely switches loading between
16 the sprung pins 66 on the recess 36 and the top of the
17 hex drive 44.

18

19 When the pumps are turned off in this configuration the
20 tool 10 will remain 'open' and 'locked' as the only
21 movement occurring is the index pin 28 moving into the
22 small apex 106.

23

24 To reset, the tool 10 is placed in tension and picked-up
25 on the upstroke. This releases the collet support sleeve
26 78 from the sprung pins 66 and allows them to move back
27 to recess 34. Switching on and off of the pumps with a
28 downstroke will return the tool 10 to the 'locked' and
29 'closed' configuration. The cycle can be resumed from
30 this point whenever fluid circulation from the tool 10 is
31 required. Alternatively the tool can be pulled out of the
32 well bore on the string.

33

1 The principal advantage of the present invention is that
2 it provides a tool for circulating fluid in a well bore
3 which can be operated without the need to land the tool
4 on a formation. This allows the tool to be operated in
5 inclined or horizontal well bores. This provides the
6 further advantage that the tool can be operated on a
7 drill string so that circulation can be used to sweep
8 cuttings from the bit back to the surface of the well.
9 Jetting fluid from the tool can also help clear blockages
10 in the well bore.

11

12 A further advantage of the present invention is that it
13 provides a tool which can be locked in the open or closed
14 position whether the tool is placed in tension or
15 compression. Additionally the hex drive allows other
16 tools to be operated below the tool regardless of the
17 configuration of the tool.

18

19 Further modifications may be made to the invention
20 hereindescribed without departing from the scope thereof.
21 For example, The actuator sleeve and the index sleeve
22 could be a unitary piece. The collet assembly could
23 comprise two sleeves, the first including the sprung pins
24 and the second including the radial ports, with the first
25 sleeve acting on the second to open the ports.